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<p>(54) Title: NOVEL AMYLOLYTIC ENZYMES DERIVED FROM THE <i>B. LICHENIFORMIS</i> α-AMYLASE, HAVING IMPROVED CHARACTERISTICS</p> <p>(57) Abstract</p> <p>The present invention relates to novel amylolytic enzymes having improved characteristics for the use in starch degradation, in textile or paper desizing and in household detergent compositions. The disclosed α-amylases show surprisingly improved properties with respect to the activity level and the combination of thermostability and a higher activity level. These improved properties make them more suitable for the use under more acidic or more alkaline conditions. The improved properties allow also the reduction of the Calcium concentration under application conditions without a loss of performance of the enzyme.</p>			

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Novel amylolytic enzymes derived from the *B.licheniformis*
 α -amylase, having improved characteristics

The present invention relates to amylolytic enzymes, particularly α -amylases which are derived from such enzymes as present in *Bacillus licheniformis*.

α -Amylases hydrolyse starch, glycogen and related poly-saccharides by cleaving internal α -1,4-glucosidic bonds at random.

Starch consists of a mixture of amylose (15-30% w/w) and amylopectin (70-85% w/w). Amylose consists of linear chains of α -1,4-linked glucose units having a molecular weight (MW) from about 60,000 to about 800,000. Amylopectin is a branched polymer containing α -1,6 branch points every 24-30 glucose units, its MW may be as high as 100 million.

Starch and especially derivatized starch or thinned starch are important for a number of technical applications, e.g. as substrate for sugar and alcohol production, as an intermediate in polymer production or as technical aid during the production of textiles and paper. Starch is also the major component of stains derived from e.g. chocolate, pap or porridge on clothes and dishes.

Thinning of starch, also called liquefaction, is a first step which is necessary in most applications of starch mentioned above. This thinning step can be very conveniently carried out using α -amylase.

The α -amylase used thus far are isolated from a wide variety of bacterial, fungal, plant and animal sources. The industrially most commonly used amylases are those isolated from *Bacilli*.

A known drawback of enzymatic reactions is that enzymes are active over a quite limited range of conditions such as pH, ionic strength and especially temperature.

The α -amylase from *B.licheniformis* is one of the most stable ones in that last respect known so far and is therefore used in applications where the

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thermostability of the enzyme is crucial. However, the stability of this enzyme depends on the calcium concentration in the application and the optimum activity is observed at neutral pH. A more thermostable variant of the *B.licheniformis* enzyme, which has the same specific activity as the wild type enzyme, has been described in PCT/EP90/01042.

It has been shown in PCT/DK93/00230 that it is possible to improve the oxidation stability of *B.licheniformis* α -amylase by replacing methionines by one of the other 19 possible amino acids. In the specified test under the given conditions one of these mutants showed a slightly higher activity level than the wild type enzyme.

Though it has been shown that it is possible to improve the stability of amylolytic enzymes, in particular α -amylase, for some detrimental conditions, there is as yet no α -amylase available which has the same or better activity under suboptimal conditions than the wild type enzyme at optimum conditions. Suboptimal conditions are herein defined as conditions which use a pH other than neutral, e.g. lower than 6.5 or higher than 7.5, and/or conditions which use a lower than optimal Ca^{2+} concentration, i.e. lower than 50 ppm.

Because in most industrial applications the conditions are at best suboptimal, the problem of diminished activity could be solved by providing an enzyme which, at optimum conditions, has a higher activity than the wild type enzyme. It would then still have sufficient activity at sub-optimal conditions. The invention provides exactly such enzymes.

The invention provides an amylolytic enzyme derived from the amylolytic enzyme of *Bacillus licheniformis* or an enzyme having at least 70%, or preferably at least 90%, amino acid identity therewith which comprises at least one change of an amino acid in its sequence to another amino acid which provides the enzyme with a higher activity than the wild type enzyme. The activity of an amylolytic enzyme is herein defined as the specific activity as determined in Example 2. The higher activity of the mutant enzymes is apparent under optimal conditions but also under

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suboptimal conditions where a pH value of less than pH 6.5 or higher than pH 7.5 and/or a Ca²⁺ concentration of less than 50 ppm is used. In addition, the invention provides such amylolytic enzymes with a higher thermostability than the wild-type enzyme, wherein the thermostability is defined as determined in Example 3. For some of the mutant enzymes, the improved thermostability is most pronounced under suboptimal conditions regarding the Ca²⁺ concentration.

The amino acid sequence of the *B.licheniformis* α -amylase is shown in Figure 1. The numbers indicate the position of an amino acid in the sequence and will be used as an indication for the amino acid position in the description of the amino acid changes. Regarding the corresponding amino acid changes in enzymes having at least 70%, or preferably at least 90%, amino acid identity with the *B.licheniformis* α -amylase, the skilled person will understand that the *B.licheniformis* α -amylase amino acid positions used herein refer to the corresponding conserved amino acids in the amino acid sequence of these related enzymes and not necessarily to their amino acid positions in those enzymes. It is also to be understood that these corresponding conserved amino acids are not necessarily identical to those of the *B.licheniformis* α -amylase.

In a site directed mutagenesis study we identified mutants on the amino acid sequence which influence the activity level of the enzyme. Among others, we made the following mutations: N104D, S187D, V128E and N188D, which are preferred mutant enzymes according to the invention. Some of these mutants showed a higher overall activity than the wild type enzyme. Alternatively, some of these mutations showed improved thermostability.

Although site directed mutations in the DNA encoding the amylolytic enzymes are a preferred way of arriving at the enzymes according to the invention, the man skilled in the art will be aware that there are different ways of obtaining the enzymes according to the invention and they are therefore part of this invention.

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Due to the fact that until now only 3D-structure of non bacterial α -amylases are available (e.g. L. Brady et al. Acta Cryst. B47 (1991), 527-535, H.J. Swift et al. Acta Cryst. B47 (1991), 535-544, M. Quian et al. J. Mol. Biol. 231 (1993), 785-799), it is hard to predict for the α -amylase from 5 *B.licheniformis* whether a certain amino acid at a certain position can have any influence on the activity level of the enzyme. One normally needs a 3D-structure for making such predictions, because the spatial orientation of the amino acids determines their role in the catalytic process. Without a 3D-structure of the investigated enzyme one has to relate the results of site 10 directed mutagenesis experiments on putative active site residues on related enzymes (see e.g. L. Holm et al. Protein Engineering 3 (1990) 181-191, M. Vihinen et al. J. Biochem. 107 (1990) 267-272, T. Nagashima et al. Biosci. Biotech. Biochem. 56 (1992) 207-210, K. Takase Eur. J. Biochem. 211 (1993) 899-902, M. Søgaard et al. J. Biol. Chem. 268 (1993) 22480-15 22484) via a multiple sequence alignment (see e.g. L. Holm et al. Protein Engineering 3 (1990) 181-191) to the known 3D-structures. This allows the identification of the active site residues and allows to identify residues which are conserved in all similar enzymes. One normally assumes that 20 conserved residues are crucial for the function or structure of the enzyme. It is therefore to be expected that mutations in those sites will influence the activity of the enzyme. By making mutations in said active sites it would therefore be expected that some mutations would result in higher activity. However, in *B.licheniformis* none of the mutated residues at position 104, 25 128, 187 and 188 are active site residues. Only position 104 is located at the end of a conserved region and could maybe be important for the activity, but also in that particular case a correct prediction of the effect of a point mutation is nearly impossible.

Another important aspect of the invention is the finding that in a number 30 of cases the higher active mutants were slightly less thermostable than the wild type enzyme, except at least the mutations V128E and N188D, which are more stable, or at least more thermostable, than the wild type enzyme.

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We therefore combined them with some earlier identified mutations which are known to stabilize the wild type enzyme. These are the mutations H133Y and T149I. These extra mutations indeed stabilized the more active mutants, but moreover they surprisingly showed an even higher activity 5 level than the higher active mutants themselves.

In a further embodiment of the invention, the mutants of the invention are combined with mutations which improve the oxidation stability of the amylolytic enzyme. Such mutant enzymes may comprise mutations known in the art to improve the oxidation stability of amylolytic enzymes, such as 10 e.g. mutations which replace the methionine at position 197 (see e.g. PCT/DK93/00230).

As stated before, a suitable way of arriving at the enzymes according to the invention is site directed mutagenesis of a nucleic acid, especially a DNA molecule, which comprises the coding sequence for the enzymes. The 15 mutated nucleic acid molecules themselves are also part of the invention representing novel and inventive intermediates in producing the enzymes. Also by providing these nucleic acids in a suitable vector format (whereby a vector is meant to include any suitable vehicle for expression in a cell), it is possible to express the nucleic acid in a vast array of different hosts, 20 including homologous and heterologous hosts, such as bacteria and/or other prokaryotes, yeasts, fungi, plant cells, insect cells or mammalian cells and or other eukaryotic host cells. These host cells which can be cultured to produce the enzymes are also part of the invention.

25 These cells can be cultured according to known techniques, which are all adapted to the particular kind of cell to be propagated. The isolation of the enzymes according to the invention from the culture or the culture supernatant is also known in the art.

A number of mutants will be more active (i.e. higher specific activity) 30 and/or more stabl (with respect t oxidation- and/or thermo-stability) even when only parts thereof are used. These fragments are of course within the

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scope of this invention. It will also be possible to design mutations based upon this invention which have hardly any influence on the activity or stability, such derivatives are also a part of this invention. Some reactive residues which are present in the amino acid sequences according to the 5 invention may also be chemically modified without having significant influence on the activity of such an enzyme. These derivatives are also a part of the invention.

The same may be stated for the nucleic acids according to the invention, which can be modified to a certain extent without influencing the important 10 properties of the resulting enzyme. Therefore nucleic acid sequences which share at least 70% identity, or more preferably at least 90 % identity, with a coding sequence for an enzyme according to the invention or which are complementary to such a sequence are part of this invention. This is also true because based on this invention it will be possible to arrive at similar 15 improvements in activity and/or stability in closely related enzymes such as amylolytic enzymes from *B.stearothermophilus* and *B.amyloliquefaciens*.

The novel amylolytic enzymes according to the invention may be used in all known applications of the amylolytic enzymes in the state of the art.

These applications include the use in the processing of starch, e.g. for 20 polymer production wherein starch needs to be "thinned", the use in detergent compositions to break down stains which comprise starch or starch derivatives, the use in production of sugar or alcohol, or the use in the processing of textile or paper, in particular, the use for desizing of textile or paper, respectively.

25 Detergent compositions comprising the novel amylolytic enzymes are also a part of the invention. These compositions may be designed for dishwashing (either by hand or automatically), for household or industrial cleaning purposes, or for cleaning textiles. These compositions may comprise the usual additives and/or ingredients such as builders, 30 surfactants, bleaching agents and the like.

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Another preferred embodiment of the invention is the use of the enzymes in producing syrup or isosyrup from starch. Syrup and isosyrup are produced using an α -amylase according to the invention which catalyzes the liquefaction (or thinning) of the starch resulting in dextrans having an average polymerization degree of about 7-10, usually followed by saccharification of the liquefied starch resulting in a syrup with a high glucose content. Optionally the syrup can be isomerized to a dextrose/fructose mixture known as isosyrup.

The invention will now be explained in more detail through the following examples, which are intended for illustration purposes only.

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Examples

Short description of the figures:

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Figure 1 gives the amino acid sequence of the α -amylase of *B.licheniformis*. The numbers relate to the positions of the amino acids in the sequence. They are used to identify the mutations, which are given in one letter amino acid code in the text of the application.

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The nomenclature used for the mutations is as follows S187D means the replacement of the serine (Ser) at position 187 against an aspartic acid (Asp). Multiple mutants are designated as follows H133Y/T149I means the replacement of histidine (His) at position 133 by tyrosine (Tyr) plus the replacement of threonine (Thr) at position 149 by isoleucine (Ile).

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Figure 2 gives a map of plasmid pBHATLAT. α -amylase: *B.licheniformis* α -amylase encoding gene. ori_{PB}: origin of replication of plasmid pUB110. rep_{PB}: replication protein of plasmid pUB110. neo: neomycin resistance gene. bleo: bleomycin resistance gene. pHpaII: HpaII promoter. ori_f: origin 20 of replication of phage f1. ori322: origin of replication of plasmid pBR322. bla: β -lactamase (ampicillin resistance) gene. cat*: inactive chloramphenicol acetyl transferase (chloramphenicol resistance) gene. pTac: Tac promoter.

25

Example 1

Production and purification of wild type and mutant α -amylases

a) Genetic procedures:

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All molecular genetic techniques used for *E.coli* (plasmid construction, transformation, plasmid isolation, etc.) were performed according to

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Maniatis *et al.* (Molecular Cloning, A Laboratory Manual, Cold Spring Harbor, 1989). Transformation of *B.subtilis* and plasmid isolation were performed according to Harwood *et al.* (Molecular Biological Methods for Bacillus, Chichester, 1990). *E.coli* strains containing pBHATLAT or its derivatives were grown in the presence of 100 mg/l ampicillin and 2 mg/l neomycin. *Bacillus subtilis* strains harboring pBHLAT 9-derived plasmids were cultivated in medium containing 20 mg/l neomycin.

Plasmid pBHA/C1 is a *Bacillus/E.coli* shuttle vector derived from the twin vector system pMa/c5-8 of Stanssens *et al.* (Nucl. Acids Res. 17 (1989): 10 4441-4454). A complete description of pBHA1 is given in the European Patent Application EP 414297.

The *B.licheniformis* α -amylase gene used throughout this study was obtained from plasmid pMcTLia6 (WO91/00353) as an EcoRI-HinDIII restriction fragment still including the inducible Tac promoter. This fragment was inserted in EcoRI-HinDIII digested pBHA1 to yield plasmid pBHATLAT (Fig. 2). This plasmid is used for the expression of α -amylase in *E.coli* through induction of the Tac promoter by 0.2 mM IPTG. Expression of mutant α -amylase was obtained by replacing the wild type α -amylase gene fragment by the corresponding mutant gene fragment. For expression in 15 Bacillus, plasmid pBHATLAT was digested with BamHI and subsequent relegation thus placing the α -amylase gene under the control of the constitutive Hpall promoter. Wild type and mutant α -amylase enzyme was isolated from the Bacillus culture supernatant.

Site directed mutagenesis of the α -amylase gene was performed using the 20 PCR overlap extension technique described by Ho *et al.* (Gene 77 (1989): 51-59).

b) Purification of the α -amylase wild type and mutants:

One aliquot of the culture supernatant is added to five aliquots water of 25 85°C and than maintained at 75°C for 15 minutes. Protease activity is removed in this step. The enzyme is then isolated via ion exchange

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chromatography at pH 5.5 on a S-Sepharose FF column. The buffers used are 20 mM sodium acetate buffer with 1 mM CaCl₂ followed, with a gradient, by 20 mM sodium acetate buffer with 1 mM CaCl₂ and 0.5 M KCl. The pooled α -amylase fractions are concentrated by ultrafiltration via a 10 5 kD filter. By washing the concentrate with 1.6 mM EDTA in 50 mM MOPS, pH 7.5 the enzyme can be demetallized. Finally the concentrate is washed twice with 50 mM MOPS buffer pH 7.5.

Example 2

10 Determination of activity and enzyme concentration

The enzyme concentration is determined by measuring the optical density at 280 nm. The extinction coefficient of wild type enzyme is 135100 M⁻¹ cm⁻¹. The mutants with the mutation H133Y have an extinction coefficient of 15 136430 M⁻¹ cm⁻¹. The molecular weight is 55 kD.

The α -Amylase activity is determined by means of the substrate para-Nitrophenyl-maltoheptaosoide (4NP-DP7). The reagent of Abbott (code LN5A23-22) is used. Besides 4NP-DP7 there is also α -glucosidase and glucoamylase in the substrate. α -Amylase activity is measured by the ultimate 20 release of the chromophore p-nitrophenol (pNP).

The terminal glucose unit of the substrate is blocked with a benzylidene group. This terminal blocking inhibits cleavage by α -glucosidase until the initial bonds can be cleaved by α -amylase followed by glucoamylase.

The increase of the OD₄₀₅ per minute is directly proportional to the α -amylase 25 activity.

The molar extinction coefficient of pNP at 405 nm and pH 6.8 is 7600 M⁻¹ cm⁻¹. 1 Unit is 1 μ mol converted substrate per minute. With the law "Lambert-Beer" the following relationship is established:

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$$\text{Activity} = \frac{\text{OD405} * 10^6}{\epsilon^{405} * l * t} = \frac{\text{OD405}}{t} * 131.6 \quad \left[\frac{\mu\text{M}}{\text{l}} \right]$$

where t = time [minutes], l = lightpath [cm], ϵ^{405} = molar extinction coefficient at 405nm [$\text{M}^{-1} * \text{cm}^{-1}$], OD405 = extinction at 405 nm, 10^6 = calculation factor from mol/l $\rightarrow \mu\text{mol/l}$

6 **Activity assay:**

- Add 0.8 ml reagent solution (R1) to a bottle R2 (Abbott).
- Heat the temperature controlled cuvette holder of the spectrophotometer to 37°C.
- Heat the activity buffer to 37°C (50 mM MOPS + 50 mM NaCl + 2 mM CaCl₂, pH 6.8).
- Add to the cuvette in the cuvette holder:
 - 500 μl reagent
 - x μl sample
 - 500 - x μl activity buffer
- 15 - Measure the increase in extinction at 405 nm during 2 minutes.
- Calculate the activity by using the above equation.

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Table 1**Specific activities of wild type (WT) and mutant α -amylases**

Enzyme	Specific Activity [Units/mg]
wild type	60
H133Y	52
H133Y/T149I	60
N104D	30
N104D/H133Y	46
N104D/H133Y/T149I	52
V128E/H133Y	62
V128E/H133Y/T149I	54
S187D	110
H133Y/S187D	155
H133Y/T149I/S187D	150
H133Y/N188D	56
H133Y/T149I/N188D	52
V128E/H133Y/S187D	142

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Example 3
Determination of thermostability

The enzyme is incubated in an oil bath at 93 °C in closed Eppendorff micro test tubes with safety lid lock (order-No. 0030 120.086). The Calcium concentration is varied whereas the ionic strength is kept constant. The buffer has at room temperature pH 7.5 which changes at the incubation temperature

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to pH 7.0. A solution f ± 0.25 mg/ml protein in 50 mM MOPS pH 7.5 is obtained by mixing the right amount of enzyme in 50mM MOPS pH 7.5 with X mM CaCl₂ + X mM K₂SO₄ + 100 mM MOPS pH 7.5 + water. The final buffer concentration must be 50 mM and the final volume should be 500 to 5 1000 µl (the best is 1000 µl). The salt composition is shown on the following table:

mM CaCl ₂	mM K ₂ SO ₄
0	15
0.25	14.75
0.5	14.5
0.75	14.25
1	14
1.25	13.75
1.5	13.5

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Example for 0.5 mM CaCl₂:

250.0 µl 100 mM MOPS pH 7.5

88.0 µl enzyme (1.42 mg/ml)

50.0 µl 5 mM CaCl₂

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72.5 µl 100 mM K₂SO₄

39.5 µl demi water

500.0 µl total volume

25

The enzyme solutions are incubated in the sealed tubes at 93 °C. 50 µl samples are taken after 0.5, 10, 20, 30, 60, 90 and 120 minutes. The residual activity is determined with the Abbott Quickstart Amylase essay (see above). The half life time is calculated by using the fitting program GraFit (Leatherbarrow, R.J. 1990 GraFit version 2.0, Eritacus Software Ltd., Staines, UK).

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Table 2

Half life of the WT and mutant α -amylases at different Ca^{2+} concentrations

Ca^{2+}	0	0.25	0.5	0.75	1	1.25	1.5
Enzyme	Half life [min]						
wild type	4.1	9.2	15.5	18.1	22.9	30.3	29.5
H133Y	nd	12.1	24.2	33.3	53.3	nd	77.0
H133Y/T149I	1.1	9.2	21.4	32.8	40.2	53.6	53.6
N104D	nd	nd	nd	nd	7.7	nd	nd
N104D/H133Y	nd	8.4	11.6	nd	14.4	nd	15.4
N104D/H133Y/T149I	nd	10.2	13.4	17.5	19.1	23.1	20.3
V128E/H133Y	nd	15.6	33.9	nd	53.3	65.3	77.8
V128E/H133Y/T149I	nd	19.7	35.2	nd	54.7	nd	76.3
S187D	nd	4.0	6.9	9.3	12.1	nd	15.1
H133Y/S187D	nd	15.2	19.7	27.0	29.8	40.8	47.2
H133Y/T149I/S187D	1.4	6.0	12.7	17.6	20.0	nd	nd
H133Y/N188D	nd	18.2	36.2	nd	70.4	76.8	84.9
H133Y/T149I/N188D	nd	15.8	28.8	nd	62.0	nd	73.6
V128E/H133Y/S187D	1.9	7.2	16.9	nd	32.1	nd	36.2

nd = not determined

20

Example 4

Starch liquefaction using a mutant α -amylase of the invention

25 The mutant enzyme was proven to be effective in starch liquefaction tests using industrially relevant conditions. It was tested under identical conditions in comparison with the wild type enzyme.

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A 34.3 % dry solids starch slurry was liquefied using a pilot plant jet cooking apparatus, Hydroheater Model # M 103-MS, at a flow rate of 2.8 l per minute. A 5 minutes retention time at 105 °C of primary liquefaction was followed by a 93 °C 120 min secondary liquefaction. The comparison tests vis a vis the wild type enzyme were performed based upon equal Modified Wohlgemuth Units (MWU) 168 units/gram of starch. The specific activity is for wild type 18,447 MWU/mg and for H133Y/S187D 48,000 MWU/mg respectively.

The enzymes were tested under two sets of conditions. The first experiment used standard industrial conditions (pH 6.4, 44 ppm Calcium), while the second experiment employed stress conditions (pH 5.8, 8 ppm Calcium).

The decrease in viscosity during liquefaction was measured with a #3 Zahn cup, while Dextrose Equivalent (DE) development was measured using a reducing sugar assay. The results are summarized in the following tables:

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Table 3.

Experiment 1: pH 6.4, 44 ppm Calcium

time [min]	Wild type		H133Y/S187D	
	DE	Viscosity	DE	Viscosity
0		25		24
20	2.7		2.4	
40	4.0		3.5	
60	5.4	14	4.7	14
80	6.5		6.0	
100	7.8		7.5	
120	9.2	12	8.8	12

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Table 4.

Experiment 2: pH 5.8, 8 ppm Calcium

		Wild type		H133Y/S187D		
		time [min]	DE	Viscosity	DE	Viscosity
5	0			36		38
	20	0.3			1.1	
	40	1.1			2.0	
	60	2.0	17		2.9	15
	80	2.5			3.5	
	100	3.2			4.2	
	120	3.9	13		4.6	13

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Example 5

Textile desizing using a mutant α -amylase of the invention

Cretonne cotton patches (30 * 30 cm, J. Hacot et Cie., 48 Rue Mermoz, La Gorgue, France) are impregnated with 12 % soluble starch (weight/weight) 20 as sizing agent. The sized cotton is given in a beaker with one litre tap water and 0.5 ml/l wetting agent at 25 °C and pH 7.0. α -Amylase is added in a concentration as shown in the table. The mixture is agitated and heated with a gradient of 2 °C per minute within 30 minutes to a final temperature of 85 °C. After 10 minutes agitating at the final temperature the fabric is 2 minutes 25 rinsed with cold water and dried.

The residual starch is determined with a reflectrometric method. The residual starch on the fibres is coloured with a solution made from 0.15 g iodine, 0.5 g potassium iodine and 10 ml 2 N H_2SO_4 in a volume of 1 l water. The dried cotton patch is wetted with alcohol and soaked in the colouring

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solution for 15 minutes. The reflectance of the coloured patch is measured at 700 nm with a Universal Messeinheit UME 1 III/LR 90 reflectometer (Dr. Bruno Lange GmbH, Berlin, Germany). The amount of residual starch can be calculated with a calibration curve recorded with known amounts of starch on the fabric.

Table 5.
A comparison of the performance of the wild type and a mutant α -amylase in
the desizing of textile.

wild type		H133Y/S187D	
enzyme concentration [$\mu\text{mol/l}$]	remaining starch on fabrics [mg/g]	enzyme concentration [$\mu\text{mol/l}$]	remaining starch on fabric [mg/g]
0	3.92	0	4.05
9.3	3.35	2.5	3.35
18.5	2.76	4.9	2.45
37.2	2.25	7.6	2.02
46.5	1.85	9.1	1.72
70	1.42	12.5	1.37
93	0.9	18.9	1.12
		25.3	0.68
		37.8	0.5

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Example 6

A comparison of the wash performance of the wild type
and a mutant α -amylase

- 5 The wash performance of the wild type vis a vis the H133Y/S187D mutant was tested in a full scale wash experiment using the amylase sensitive cotton test fabric EMPA 112 as monitor. In all tests the α -amylase dosage was 1.3 mg/l suds. A blank was taken as reference. Washing powder base was the IEC reference detergent A, containing bleach and protease.
- 10 All tests were carried out in quintuple. The fabrics were washed in a Miele, type W701 washing machine at 40 °C and a total load of 4 kg fabrics. The soil removal was determined by measuring the white light reflection with a Colorgard Model 05 (Gardner Lab., USA) reflectometer. Table summarizes the results. It shows that the mutant performs better than wild type enzyme at
- 15 the same dosage.

Table 6.

A comparison of the wash performance of the wild type and a mutant α -amylase

20	Enzyme	none	wild type	H133Y/S187D
	Soil removal	31.7 %	40.2 %	42.1 %

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SEQUENCE LISTING

(1) GENERAL INFORMATION:

5

(i) APPLICANT:

- (A) NAME: Gist-brocades B.V.
- (B) STREET: Wateringseweg 1
- (C) CITY: Delft
- 10 (E) COUNTRY: The Netherlands
- (F) POSTAL CODE (ZIP): 2611 XT

(ii) TITLE OF INVENTION: Alpha-amylase mutants

15

(iii) NUMBER OF SEQUENCES: 2

(iv) COMPUTER READABLE FORM:

20

- (A) MEDIUM TYPE: Floppy disk
- (B) COMPUTER: IBM PC compatible
- (C) OPERATING SYSTEM: PC-DOS/MS-DOS
- (D) SOFTWARE: PatentIn Release #1.0, Version #1.25 (EPO)

- 20 -

(2) INFORMATION FOR SEQ ID NO: 1:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 1539 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: double
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: NO

(iii) ANTI-SENSE: NO

(vi) ORIGINAL SOURCE:

- (A) ORGANISM: *Bacillus licheniformis*
- (B) STRAIN: CBS407.83

(ix) FEATURE:

- (A) NAME/KEY: CDS
- (B) LOCATION: 1..1539

(ix) FEATURE:

- (A) NAME/KEY: sig_peptide
- (B) LOCATION: 1..87

(ix) FEATURE:

- (A) NAME/KEY: mat_peptide
- (B) LOCATION: 88..1539

(D) OTHER INFORMATION: /product= "alpha-amylase"

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 1:

35 ATG AAA CAA CAA AAA CGG CTT TAC GCC CGA TTG CTG ACG CTG TTA TTT
 Met Lys Gln Gln Lys Arg Leu Tyr Ala Arg Leu Leu Thr Leu Leu Phe
 -29 -25 -20 -15

48

40 GCG CTC ATC TTC TTG CTG CCT CAT TCT GCA GCA GCG GCG GCA AAT CTT
 Ala Leu Ile Phe Leu Leu Pro His Ser Ala Ala Ala Ala Asn Leu
 -10 -5 1

96

AAT GGG ACG CTG ATG CAG TAT TTT GAA TGG TAC ATG CCC AAT GAC GGC

144

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	Asn Gly Thr Leu Met Gln Tyr Phe Glu Trp Tyr Met Pro Asn Asp Gly		
5	10	15	
5	CAA CAT TGG AAG CGT TTG CAA AAC GAC TCG GCA TAT TTG GCT GAA CAC Gln His Trp Lys Arg Leu Gln Asn Asp Ser Ala Tyr Leu Ala Glu His		192
20	25	30	35
10	GGT ATT ACT GCC GTC TGG ATT CCC CCG GCA TAT AAG GGA ACT AGT CAA Gly Ile Thr Ala Val Trp Ile Pro Pro Ala Tyr Lys Gly Thr Ser Gln		240
40	45	50	
15	GCG GAT GTG GGC TAC GGT GCT TAC GAC CTT TAT GAT TTA GGG GAG TTT Ala Asp Val Gly Tyr Gly Ala Tyr Asp Leu Tyr Asp Leu Gly Glu Phe		288
55	60	65	
20	CAT CAA AAA GGG ACG GTT CCG ACA AAG TAC GGC ACA AAA GGA GAG CTG His Gln Lys Gly Thr Val Arg Thr Lys Tyr Gly Thr Lys Gly Glu Leu		336
70	75	80	
25	GAT GTG GTC ATC AAC CAC AAA GGC GGC GCT GAT GCG ACC GAA GAT GTA Asp Val Val Ile Asn His Lys Gly Gly Ala Asp Ala Thr Glu Asp Val		384
100	105	110	115
30	ACC GCG GTT GAA GTC GAT CCC GCT GAC CGC AAC CGC GTA ATT TCA GGA Thr Ala Val Glu Val Asp Pro Ala Asp Arg Asn Arg Val Ile Ser Gly		432
120	125	130	
35	GAA CAC CTA ATT AAA GCC TGG ACA CAT TTT CAT TTT CCG GGG CGC GGC Glu His Leu Ile Lys Ala Trp Thr His Phe His Phe Pro Gly Arg Gly		480
135	140	145	
40	AGC ACA TAC AGC GAT TTT AAA TGG CAT TGG TAC CAT TTT GAC GGA ACC Ser Thr Tyr Ser Asp Phe Lys Trp His Trp Tyr His Phe Asp Gly Thr		528
150	155	160	
45	GAT TGG GAC GAG TCC CGA AAG CTG AAC CGC ATC TAT AAG TTT CAA GGA Asp Trp Asp Glu Ser Arg Lys Leu Asn Arg Ile Tyr Lys Phe Gln Gly		576
165	170	175	

- 22 -

	AAG GCT TGG GAT TGG GAA GTT TCC AAT GAA AAC GGC AAC TAT GAT TAT		672
	Lys Ala Trp Asp Trp Glu Val Ser Asn Glu Asn Gly Asn Tyr Asp Tyr		
180	185	190	195
5	TTG ATG TAT GCC GAC ATC GAT TAT GAC CAT CCT GAT GTC GCA GCA GAA		720
	Leu Met Tyr Ala Asp Ile Asp Tyr Asp His Pro Asp Val Ala Ala Glu		
	200	205	210
10	ATT AAG AGA TGG GGC ACT TGG TAT GCC AAT GAA CTG CAA TTG GAC GGT		768
	Ile Lys Arg Trp Gly Thr Trp Tyr Ala Asn Glu Leu Gln Leu Asp Gly		
	215	220	225
15	TTC CGT CTT GAT GCT GTC AAA CAC ATT AAA TTT TCT TTT TTG CGG GAT		816
	Phe Arg Leu Asp Ala Val Lys His Ile Lys Phe Ser Phe Leu Arg Asp		
	230	235	240
20	TGG GTT AAT CAT GTC AGG GAA AAA ACG GGG AAG GAA ATG TTT ACG GTA		864
	Trp Val Asn His Val Arg Glu Lys Thr Gly Lys Glu Met Phe Thr Val		
	245	250	255
25	GCT GAA TAT TGG CAG AAT GAC TTG GGC GCC CTG GAA AAC TAT TTG AAC		912
	Ala Glu Tyr Trp Gln Asn Asp Leu Gly Ala Leu Glu Asn Tyr Leu Asn		
	260	265	270
30	AAA ACA AAT TTT AAT CAT TCA GTG TTT GAC GTG CCG CTT CAT TAT CAG		960
	Lys Thr Asn Phe Asn His Ser Val Phe Asp Val Pro Leu His Tyr Gln		
	280	285	290
35	TTC CAT GCT GCA TCG ACA CAG GGA GGC GGC TAT GAT ATG AGG AAA TTG		1008
	Phe His Ala Ala Ser Thr Gln Gly Gly Tyr Asp Met Arg Lys Leu		
	295	300	305
40	CTG AAC GGT ACG GTC GTT TCC AAG CAT CCG TTG AAA TCG GTT ACA TTT		1056
	Leu Asn Gly Thr Val Val Ser Lys His Pro Leu Lys Ser Val Thr Phe		
	310	315	320
45	GTC GAT AAC CAT GAT ACA CAG CCG GGG CAA TCG CTT GAG TCG ACT GTC		1104
	Val Asp Asn His Asp Thr Gln Pro Gly Gln Ser Leu Glu Ser Thr Val		
	325	330	335
50	CAA ACA TGG TTT AAG CCG CTT GCT TAC GCT TTT ATT CTC ACA AGG GAA		1152
	Gln Thr Trp Phe Lys Pro Leu Ala Tyr Ala Phe Ile Leu Thr Arg Glu		
	340	345	350
			355

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TCT GGA TAC CCT CAG GTT TTC TAC GGG GAT ATG TAC GGG ACG AAA GGA			1200
Ser Gly Tyr Pro Gln Val Phe Tyr Gly Asp Met Tyr Gly Thr Lys Gly			
360	365	370	
5 GAC TCC CAG CGC GAA ATT CCT GCC TTG AAA CAC AAA ATT GAA CCG ATC			1248
Asp Ser Gln Arg Glu Ile Pro Ala Leu Lys His Lys Ile Glu Pro Ile			
375	380	385	
10 TTA AAA GCG AGA AAA CAG TAT GCG TAC GGA GCA CAG CAT GAT TAT TTC			1296
Leu Lys Ala Arg Lys Gln Tyr Ala Tyr Gly Ala Gln His Asp Tyr Phe			
390	395	400	
15 GAC CAC CAT GAC ATT GTC GGC TGG ACA AGG GAA GGC GAC AGC TCG GTT			1344
Asp His His Asp Ile Val Gly Trp Thr Arg Glu Gly Asp Ser Ser Val			
405	410	415	
20 GCA AAT TCA GGT TTG GCG GCA TTA ATA ACA GAC GGA CCC GGT GGG GCA			1392
Ala Asn Ser Gly Leu Ala Ala Leu Ile Thr Asp Gly Pro Gly Gly Ala			
420	425	430	435
25 AAG CGA ATG TAT GTC GGC CGG CAA AAC GCC GGT GAG ACA TGG CAT GAC			1440
Lys Arg Met Tyr Val Gly Arg Gln Asn Ala Gly Glu Thr Trp His Asp			
440	445	450	
30 ATT ACC GGA AAC CGT TCG GAG CCG GTT GTC ATC AAT TCG GAA GGC TGG			1488
Ile Thr Gly Asn Arg Ser Glu Pro Val Val Ile Asn Ser Glu Gly Trp			
455	460	465	
35 GGA GAG TTT CAC GTA AAC GGC GGG TCG GTT TCA ATT TAT GTT CAA AGA			1536
Gly Glu Phe His Val Asn Gly Gly Ser Val Ser Ile Tyr Val Gln Arg			
470	475	480	
TAG			
36 1539			

40 (2) INFORMATION FOR SEQ ID NO: 2:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 512 amino acid

- 24 -

(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

6

(xi) SEQUENCE DESCRIPTION: SEQ ID NO: 2:

Met Lys Gln Gln Lys Arg Leu Tyr Ala Arg Leu Leu Thr Leu Leu Phe
10 -29 -25 -20 -15

Ala Leu Ile Phe Leu Leu Pro His Ser Ala Ala Ala Ala Asn Leu
-10 -5 1

15 Asn Gly Thr Leu Met Gln Tyr Phe Glu Trp Tyr Met Pro Asn Asp Gly
5 10 15

Gln His Trp Lys Arg Leu Gln Asn Asp Ser Ala Tyr Leu Ala Glu His
20 25 30 35

20 Gly Ile Thr Ala Val Trp Ile Pro Pro Ala Tyr Lys Gly Thr Ser Gln
40 45 50

Ala Asp Val Gly Tyr Gly Ala Tyr Asp Leu Tyr Asp Leu Gly Glu Phe
25 55 60 65

His Gln Lys Gly Thr Val Arg Thr Lys Tyr Gly Thr Lys Gly Glu Leu
70 75 80

30 Gln Ser Ala Ile Lys Ser Leu His Ser Arg Asp Ile Asn Val Tyr Gly
85 90 95

Asp Val Val Ile Asn His Lys Gly Gly Ala Asp Ala Thr Glu Asp Val
100 105 110 115

35 Thr Ala Val Glu Val Asp Pro Ala Asp Arg Asn Arg Val Ile Ser Gly
120 125 130

40 Glu His Leu Ile Lys Ala Trp Thr His Phe His Phe Pro Gly Arg Gly
135 140 145

Ser Thr Tyr Ser Asp Phe Lys Trp His Trp Tyr His Phe Asp Gly Thr

- 25 -

	150	155	160
	Asp Trp Asp Glu Ser Arg Lys Leu Asn Arg Ile Tyr Lys Phe Gln Gly		
	165	170	175
5	Lys Ala Trp Asp Trp Glu Val Ser Asn Glu Asn Gly Asn Tyr Asp Tyr		
	180	185	190
	Leu Met Tyr Ala Asp Ile Asp Tyr Asp His Pro Asp Val Ala Ala Glu		
10	200	205	210
	Ile Lys Arg Trp Gly Thr Trp Tyr Ala Asn Glu Leu Gln Leu Asp Gly		
	215	220	225
15	Phe Arg Leu Asp Ala Val Lys His Ile Lys Phe Ser Phe Leu Arg Asp		
	230	235	240
	Trp Val Asn His Val Arg Glu Lys Thr Gly Lys Glu Met Phe Thr Val		
	245	250	255
20	Ala Glu Tyr Trp Gln Asn Asp Leu Gly Ala Leu Glu Asn Tyr Leu Asn		
	260	265	270
	Lys Thr Asn Phe Asn His Ser Val Phe Asp Val Pro Leu His Tyr Gln		
25	280	285	290
	Phe His Ala Ala Ser Thr Gln Gly Gly Tyr Asp Met Arg Lys Leu		
	295	300	305
30	Leu Asn Gly Thr Val Val Ser Lys His Pro Leu Lys Ser Val Thr Phe		
	310	315	320
	Val Asp Asn His Asp Thr Gln Pro Gly Gln Ser Leu Glu Ser Thr Val		
	325	330	335
35	Gln Thr Trp Phe Lys Pro Leu Ala Tyr Ala Phe Ile Leu Thr Arg Glu		
	340	345	350
	Ser Gly Tyr Pro Gln Val Phe Tyr Gly Asp Met Tyr Gly Thr Lys Gly		
40	360	365	370
	Asp Ser Gln Arg Glu Ile Pro Ala Leu Lys His Lys Ile Glu Pro Ile		
	375	380	385

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Leu Lys Ala Arg Lys Gln Tyr Ala Tyr Gly Ala Gln His Asp Tyr Phe
390 395 400

Asp His His Asp Ile Val Gly Trp Thr Arg Glu Gly Asp Ser Ser Val
5 405 410 415

Ala Asn Ser Gly Leu Ala Ala Leu Ile Thr Asp Gly Pro Gly Gly Ala
420 425 430 435

10 Lys Arg Met Tyr Val Gly Arg Gln Asn Ala Gly Glu Thr Trp His Asp
 440 445 450

Ile Thr Gly Asn Arg Ser Glu Pro Val Val Ile Asn Ser Glu Gly Trp
 455 460 465
15 Gly Glu Phe His Val Asn Gly Gly Ser Val Ser Ile Tyr Val Gln Arg
 470 475 480

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Claims

1. An amylolytic enzyme derived from an α -amylase of *Bacillus licheniformis* or an enzyme having at least 70% amino acid identity therewith which comprises one or more amino acid changes at positions selected from the group consisting of positions 104, 128, 187 and 188 of the amino acid sequence of the α -amylase of *Bacillus licheniformis*.
2. An enzyme according to claim 1, wherein one or more of the amino acid changes are selected from the group consisting of Asn at position 104 to Asp, Val at position 128 to Glu, Ser at position 187 to Asp, and Asn at position 188 to Asp.
3. An enzyme according to any one of claims 1 or 2, which comprises at least one additional amino acid change providing the enzyme with improved thermostability.
4. An enzyme according to claim 3, wherein at least one additional amino acid change selected from the group consisting of His at position 133 to Tyr, and Thr at position 149 to Ile.
5. An enzyme according to any one of claims 1-4, which comprises at least one additional amino acid change providing the enzyme with improved oxidation stability.
6. An enzyme according to claim 5, wherein the additional amino acid change comprises a change of a methionine to another amino acid.
7. An enzyme according to claim 6, wherein the methionine is the methionine at position 197.

30

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8. A nucleic acid molecule encoding an enzyme according to any one of the claims 1-7 or a nucleic acid complementary to said nucleic acid or a nucleic acid which hybridizes to either of said nucleic acids under moderately stringent conditions.
- 5
9. A vector for expression of an enzyme according to any one of the claims 1-7, comprising a nucleic acid according to claim 8, together with suitable elements for expression.
- 10 10. A cell for expressing an enzyme according to any one of claims 1-7, comprising a nucleic acid molecule or a vector according to claims 8 or 9, respectively.
11. A process for producing an enzyme according to any one of claims 1-7, which comprises culturing a cell according to claim 10 in a suitable medium for expression of said enzyme and after a suitable amount of time isolating the enzyme from the culture or the culture supernatant.
- 15
12. Use of an enzyme according to any one of the claim 1-7 in the processing of starch, in the production of syrups, isosyrups, or ethanol, in the desizing of textiles or paper, in brewing processes, in detergents or in the beverage industry.
- 20
13. A detergent composition comprising an enzyme according to any one of claims 1-7.
- 25

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Figure 1:

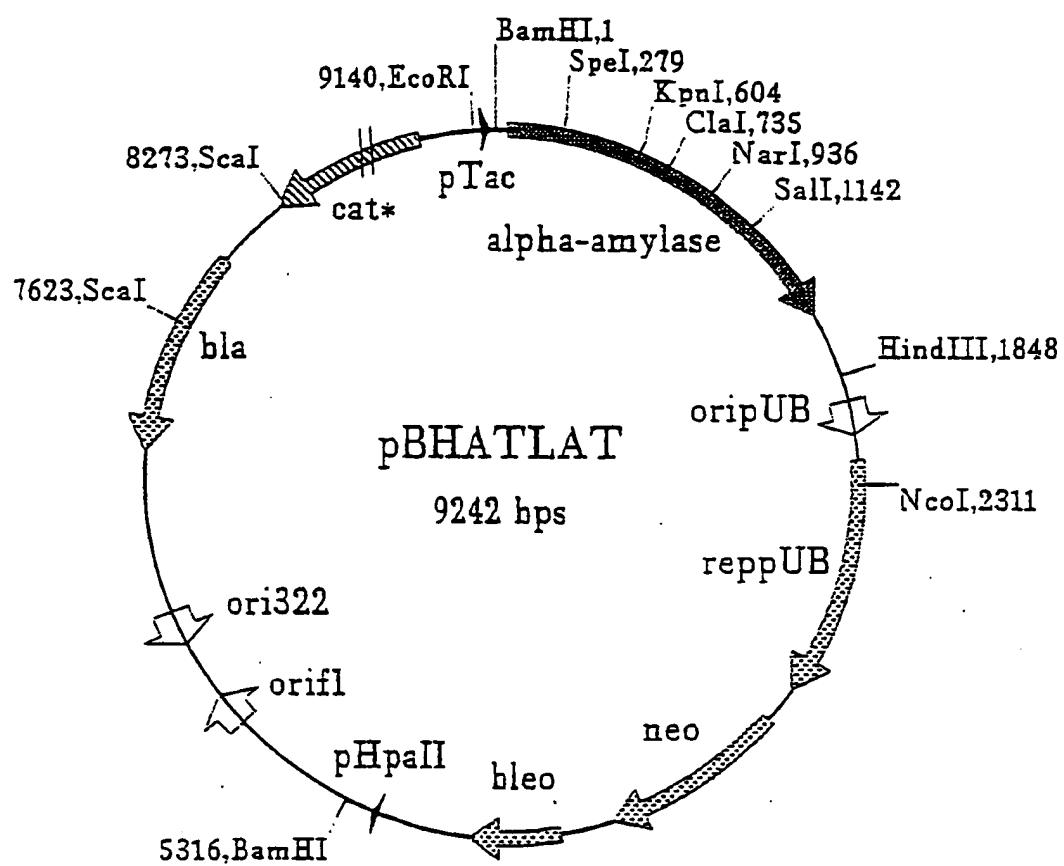
5	10	15
ALA ASN LEU ASN GLY THR LEU MET GLN TYR PHE GLU TRP TYR MET		
20	25	30
PRO ASN ASP GLY GLN HIS TRP LYS ARG LEU GLN ASN ASP SER ALA		
35	40	45
TYR LEU ALA GLU HIS GLY ILE THR ALA VAL TRP ILE PRO PRO ALA		
50	55	60
TYR LYS GLY THR SER GLN ALA ASP VAL GLY TYR GLY ALA TYR ASP		
65	70	75
LEU TYR ASP LEU GLY GLU PHE HIS GLN LYS GLY THR VAL ARG THR		
80	85	90
LYS TYR GLY THR LYS GLY GLU LEU GLN SER ALA ILE LYS SER LEU		
95	100	105
HIS SER ARG ASP ILE ASN VAL TYR GLY ASP VAL VAL ILE ASN HIS		
110	115	120
LYS GLY GLY ALA ASP ALA THR GLU ASP VAL THR ALA VAL GLU VAL		
125	130	135
ASP PRO ALA ASP ARG ASN ARG VAL ILE SER GLY GLU HIS LEU ILE		
140	145	150
LYS ALA TRP THR HIS PHE HIS PHE PRO GLY ARG GLY SER TER TYR		
155	160	165
SER ASP PHE LYS TRP HIS TRP TYR HIS PHE ASP GLY TER ASP TRP		
170	175	180
ASP GLU SER ARG LYS LEU ASN ARG ILE TYR LYS PHE GLN GLY LYS		
185	190	195
ALA TRP ASP TRP GLU VAL SER ASN GLU ASN GLY ASN TYR ASP TYR		
200	205	210
LEU MET TYR ALA ASP ILE ASP TYR ASP HIS PRO ASP VAL ALA ALA		
215	220	225
GLU ILE LYS ARG TRP GLY THR TRP TYR ALA ASN GLU LEU GLN LEU		
230	235	240
ASP GLY PHE ARG LEU ASP ALA VAL LYS HIS ILE LYS PHE SER PHE		
245	250	255
LEU ARG ASP TRP VAL ASN HIS VAL ARG GLU LYS THR GLY LYS GLU		
260	265	270
MET PHE THR VAL ALA GLU TYR TRP GLN ASN ASP LEU GLY ALA LEU		

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275	280	285
GLU ASN TYR LEU ASN LYS THR ASN PHE ASN HIS SER VAL PHE ASP		
290	295	300
VAL PRO LEU HIS TYR GLN PHE HIS ALA ALA SER THR GLN GLY GLY		
305	310	315
GLY TYR ASP MET ARG LYS LEU LEU ASN GLY THR VAL VAL SER LYS		
320	325	330
HIS PRO LEU LYS SER VAL THR PHE VAL ASP ASN HIS ASP THR GLN		
335	340	345
PRO GLY GLN SER LEU GLU SER THR VAL GLN THR TRP PHE LYS PRO		
350	355	360
LEU ALA TYR ALA PHE ILE LEU THR ARG GLU SER GLY TYR PRO GLN		
365	370	375
VAL PHE TYR GLY ASP MET TYR GLY THR LYS GLY ASP SER GLN ARG		
380	385	390
GLU ILE PRO ALA LEU LYS HIS LYS ILE GLU PRO ILE LEU LYS ALA		
495	400	405
ARG LYS GLN TYR ALA TYR GLY ALA GLN HIS ASP TYR PHE AS? HIS		
410	415	420
HIS AS? ILE VAL GLY TRP THR ARG GLU GLY ASP SER SER VAL ALA		
425	430	435
ASN SER GLY LEU ALA ALA LEU ILE THR ASP GLY PRO GLY GLY ALA		
440	445	450
LYS ARG MET TYR VAL GLY ARG GLN ASN ALA GLY GLU TER TRP HIS		
455	460	465
ASP ILE THR GLY ASN ARG SER GLU PRO VAL VAL ILE ASN SER GLU		
470	475	480
GLY TRP GLY GLU PHE HIS VAL ASN GLY GLY SER VAL SER ILE TYR		
485		
VAL GLN ARG		

Figure 2:

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WORLD INTELLECTUAL PROPERTY ORGANIZATION



INTERNATIONAL APPLICATION PUBLISHED I

WO 9535382A3

(51) International Patent Classification 6 :	C12N 9/28, 15/56, 15/75, C12P 19/14, C11D 3/386, D06M 16/00, C12S 11/00 // D06M 101/04	A3	(11) International Publication Number: WO 9535382A3
(21) International Application Number:	PCT/EP95/01688	(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).	
(22) International Filing Date:	2 May 1995 (02.05.95)	(30) Priority Data: 94201740.1 17 June 1994 (17.06.94) EP (34) Countries for which the regional or international application was filed: NL et al.	(43) International Publication Date: 28 December 1995 (28.12.95)
(71) Applicant (for all designated States except US): GIST-BROCADES B.V. [NL/NL]; Wateringseweg 1, P.O. Box 1, NL-2600 MA Delft (NL).	(72) Inventors; and (75) Inventors/Applicants (for US only): VAN DER LAAN, Jan, Metske [NL/NL]; Leursebaan 364, NL-4839 AP Breda (NL). AEHLE, Wolfgang [NL/NL]; Lumumbasingel 7, NL-2622 ED Delft (NL).	(74) Agents: VISSER-LUIRINK, Gesina et al.; Gist-Brocades N.V., Patents and Trademarks Dept., Wateringseweg 1, P.O. Box 1, NL-2600 MA Delft (NL).	(81) Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(88) Date of publication of the international search report: 1 February 1996 (01.02.96)			

(54) Title: NOVEL AMYLOLYTIC ENZYMES DERIVED FROM THE *B. LICHENIFORMIS* α -AMYLASE, HAVING IMPROVED CHARACTERISTICS

(57) Abstract

The present invention relates to novel amylolytic enzymes having improved characteristics for the use in starch degradation, in textile or paper desizing and in household detergent compositions. The disclosed α -amylases show surprisingly improved properties with respect to the activity level and the combination of thermostability and a higher activity level. These improved properties make them more suitable for the use under more acidic or more alkaline conditions. The improved properties allow also the reduction of the Calcium concentration under application conditions without a loss of performance of the enzyme.

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GA	Gabon				

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 95/01688

A. CLASSIFICATION OF SUBJECT MATTER					
IPC 6 C12N9/28	C12N15/56	C12N15/75	C12P19/14	C11D3/386	
D06M16/00	C12S11/00		//D06M101:04		

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C12N C12P C11D D06M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR,A,2 676 456 (INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE) 20 November 1992 see the whole document ----	1-3,5, 8-13
X	WO,A,94 02597 (NOVO NORDISK) 3 February 1994 see the whole document ----	1,5,8-13
X	WO,A,91 00353 (GIST-BROCADES) 10 January 1991 cited in the application see the whole document ----	1-3,5, 8-13
P,X	WO,A,94 18314 (GENENCOR INTERNATIONAL INC.) 18 August 1994 see page 64 - page 68 -----	1-13

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Patent family members are listed in annex.

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- "&" document member of the same patent family

1

Date of the actual completion of the international search

14 December 1995

Date of mailing of the international search report

05.01.96

Name and mailing address of the ISA

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Authorized officer

Moreau, J

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 95/01688

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
FR-A-2676456	20-11-92	NONE		
WO-A-9402597	03-02-94	EP-A- FI-A-	0651794 950263	10-05-95 20-01-95
WO-A-9100353	10-01-91	AU-B- AU-B- CA-A- CN-A- EP-A- JP-T- US-A-	638263 5953890 2030554 1050220 0410498 4500756 5364782	24-06-93 17-01-91 30-12-90 27-03-91 30-01-91 13-02-92 15-11-94
WO-A-9418314	18-08-94	AU-B- FI-A- NO-A-	6239294 953797 953147	29-08-94 10-08-95 28-09-95

INTERNATIONAL SEARCH REPORT

Application No

PCT/EP 99/03563

A. CLASSIFICATION OF SUBJECT MATTER

IPC 5 C11D3/386 C11D3/39

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C11D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 07818 A (PROCTER & GAMBLE) 26 February 1998 (1998-02-26) Claims 1,3-5,7,8,10 examples 9,12 page 11, paragraph 2 -page 12, paragraph 1 page 35, paragraph 2 -page 37, paragraph 2 ---	1-4,6, 9-11
X	WO 96 28531 A (PROCTER & GAMBLE) 19 September 1996 (1996-09-19) claims 1,7,9-13 page 7, paragraph 2 page 11, paragraph 4 -page 22, paragraph 2 ---	1-4,9-11
A	-/-	6-8

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

Date of mailing of the international search report

22 September 1999

05/10/1999

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INTERNATIONAL SEARCH REPORT

Application No

PCT/EP 99/03563

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 99 00478 A (PROCTER & GAMBLE) 7 January 1999 (1999-01-07) claims 1-5 examples page 6, line 22 -page 7, line 17 page 18, line 14 -page 21, line 11 ---	1,3,4,6, 9-11
A	DE 196 44 591 A (HENKEL ECOLAB) 30 April 1998 (1998-04-30) claims column 5, line 61 -column 7, line 40 ---	1-11
A	DE 195 01 120 A (HENKEL KGAA) 18 July 1996 (1996-07-18) claims page 2, line 6 - line 11 page 5, line 19 - line 53 ---	1-4,6-9
A	WO 95 17495 A (PROCTER & GAMBLE) 29 June 1995 (1995-06-29) claims 1-4,7-10 page 2, last paragraph -page 4, paragraph 3 -----	1-4,6-11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 99/03563

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9807818	A	26-02-1998	AU	3879897 A	06-03-1998
			AU	6953696 A	06-03-1998
			EP	0918838 A	02-06-1999
			WO	9807822 A	26-02-1998
WO 9628531	A	19-09-1996	AU	4984996 A	02-10-1996
			BR	9607217 A	07-07-1998
			CA	2214266 A	19-09-1996
			CZ	9702837 A	18-02-1998
			EP	0815192 A	07-01-1998
			HU	9802080 A	28-12-1998
			US	5929018 A	27-07-1999
WO 9900478	A	07-01-1999	NONE		
DE 19644591	A	30-04-1998	WO	9818899 A	07-05-1998
			EP	0937132 A	25-08-1999
DE 19501120	A	18-07-1996	AT	177778 T	15-04-1999
			DE	59601455 D	22-04-1999
			WO	9622354 A	25-07-1996
			EP	0804534 A	05-11-1997
			ES	2130781 T	01-07-1999
WO 9517495	A	29-06-1995	EP	0628624 A	14-12-1994
			CA	2176696 A	29-06-1995
			CA	2176697 A	29-06-1995
			CN	1138346 A	18-12-1996
			EP	0736085 A	09-10-1996
			JP	9507509 T	29-07-1997
			WO	9517496 A	29-06-1995
			US	5883064 A	16-03-1999